(on transmit) or at very low powers (on receive). The use of such systems at high powers can result in the unwanted generation of intermodulation products that can de-sensitise the base station receiver.

Further solutions exist that use electrical phase shifters in the antenna housing, these phase shifters being remotely controllable, and so providing an easy to adjust beam pattern. Another problem with this approach is that any phase shifts will apply to all signals transmitted by the antenna, and all signals received by the antenna. Thus independent control of electrical tilt is not possible.

The above approach to generating a variable angle of electrical tilt may be applied to changing the beam pattern in the horizontal plane, such as may be required when an operator wishes to redirect a beam slightly to adjust cell coverage. Again, the same problems associated with the phase shifters will arise.

It is an aim of the current invention to provide an antenna interface able to provide independent control of antenna parameters that alleviate at least some of the problems of the prior art.

According to the present invention there is provided a base station for communicating signals between an operator and one or more mobile units by means of an antenna system having a plurality of radiating elements, characterised in that:

the system is arranged to process the signals as a plurality of component signals, each component signal being associated with one or more radiating elements within the antenna system, and

modulating means are arranged to apply complex weights to the component signals such that summation of the component signals results in the production of an antenna beam direction dependent on the value of the complex weights, and

wherein splitting, combining, and component signal amplifying means is provided between the application of the complex weight to the component signal and the component signal passing through its associated radiating element or elements, the splitting and combining means being arranged such that it allows other operators to be connected to the same antenna system.

The invention is particularly suitable for combining independent signals from different operators, as each operator requires no knowledge of any of the signals but its own, in order to control its beam pattern. An operator can control its beam pattern – either its receive beam or its transmit beam – by means of controlling the complex amplitude (i.e. phase and/or amplitude) of the component signals

Preferably the complex amplitude of the component signals is controlled by means of a vector controller (VC). This is a device that manipulates a signal by summing together amounts of in-phase and quadrature versions of itself, the amount of each decided by means of a baseband or low frequency multiplier signal, which can have a negative value. In this way, full control of the amplitude and phase of the VC output relative to the VC input is possible. However, a VC that is arranged to control, or modulate, only the phase of a signal may be used in some implementations of the invention.

Controlling the component signals in this fashion allows the electrical tilt of the beam on either transmit or receive to be tailored to the requirements of the operator, if the component signals are provided to an antenna system having spatial diversity in the vertical axis.

Likewise, the invention allows the radiation pattern to be controlled in the horizontal axis also, if component signals are arranged to be provided to an antenna system having spatial diversity in the horizontal axis.

The problems of the prior art, as discussed above, are avoided by means of this invention, as the phase and amplitude control and adjustment is done at

According to another aspect of the invention there is provided a method of controlling the direction of a transmit beam produced by an antenna connected to at least two base stations, the method comprising:

in a first base station, splitting a first signal to be transmitted into a plurality of component signals;

applying a complex weight or weights to at least one of the component signals, thereby changing the phase and/or amplitude of the component signal relative to at least one other of the component signals;

passing the component signals to amplifying and combining means wherein the signals are brought to a power level suitable for transmission, and the component signals are combined with component signals from a second base station;

passing the combined component signals to antenna elements or groups of elements, such that transmission by the elements causes a beam of energy representative of the first signal to be formed in a direction governed by the complex weight or weights.

According to a further aspect of the invention there is provided a method of controlling the direction of a receive beam produced by an antenna connected to at least two base stations, the method comprising:

receiving in the antenna a plurality of component signals, each relating to a receiving element or group of receiving elements;

separating using splitting and filter means the component signals intended for a first base station, and amplifying said component signals using amplification means;

applying a complex weight or weights to at least one of the component signals in the first base station, thereby changing the phase and/or amplitude of the component signal relative to at least one other of the component signals;

combining the component signals in a beamformer in the first base station to produce a receive beam formed in a direction governed by the complex weight or weights.

Claims

1. A base station for communicating signals between an operator and one or more mobile units by means of an antenna system having a plurality of radiating elements, characterised in that:

the system is arranged to process the signals as a plurality of component signals, each component signal being associated with one or more radiating elements within the antenna system, and

modulating means are arranged to apply complex weights to the component signals such that summation of the component signals results in the production of an antenna beam direction dependent on the value of the complex weights, and

wherein splitting, combining, and component signal amplifying means is provided between the application of the complex weight to the component signal and the component signal passing through its associated radiating element or elements, the splitting and combining means being arranged such that it allows other operators to be connected to the same antenna system.

2. A base station as claimed in claim 1 wherein calibrating means is incorporated for the purpose of measuring characteristics of the components signals at a point remote from the base station.

3. A base station as claimed in claim 2 wherein the calibration means is mounted in the vicinity of the antenna, and is able to be switched so as to measure characteristics of component signals generated by any operator connected to the antenna.

4. A base station as claimed in any of claims 1 to 3 arranged to apply the complex weights to the component signals at a component signal frequency lower than the component signal frequency that is passed to the antenna.

5. A base station as claimed in any of claims 1 to 3 wherein the base station is arranged to apply the complex weights to the component signals at

a component signal frequency substantially the same as the component signal frequency that is passed to the antenna.

6. A base station as claimed in any of claims 1 to 5 wherein the modulating means comprises vector controllers.

7. A base station as claimed in claim 6 wherein the vector controllers are arranged to control the relative phase of each component signal.

8. A base station as claimed in any of claims 6 or 7 wherein the vector controllers are arranged to control the amplitude of the component signal.

9. A base station as claimed in any of the above claims wherein calibration means is provided that is able to compensate for signal path differences between the base station and the antenna system.

10. A base station system comprising of a plurality of individual base stations characterised in that each individual base station is a base station as claimed in claim 1, and the plurality of base stations are connected to a common antenna system via interface means, the interface means itself comprising amplifying, splitting and combining means.

11 A base station for communicating signals between an operator and one or more mobile units by means of an antenna system having a plurality of radiating elements, characterised in that:

the system is arranged to process the signals as a plurality of component signals, each component signal being associated with one or more radiating elements within the antenna system, and

modulating means is arranged to apply complex weights to the component signals such that summation of the component signals results in the production of a beam dependent on the value of the complex weights, and

wherein the component signals are suitable for connection to the splitting and combining means of a base station as claimed in claim 1.

12. A method of controlling the direction of a transmit beam produced by an antenna connected to at least two base stations, the method comprising:

in a first base station, splitting a first signal to be transmitted into a plurality of component signals;

applying a complex weight or weights to at least one of the component signals, thereby changing the phase and/or amplitude of the component signal relative to at least one other of the component signals;

passing the component signals to amplifying and combining means wherein the signals are brought to a power level suitable for transmission, and the component signals are combined with component signals from a second base station;

passing the combined component signals to antenna elements or groups of elements, such that transmission by the elements causes a beam of energy representative of the first signal to be formed in a direction governed by the complex weight or weights.

13. A method as claimed in claim 12 wherein the component signals from the second base station are combined with the component signals from the first base station using combining and filtering means.

14. A method as claimed in claim 13 wherein the signals generated by the second base station are independent from those generated by the first base station.

15. A method of controlling the direction of a receive beam produced by an antenna connected to at least two base stations, the method comprising:

receiving in the antenna a plurality of component signals, each relating to a receiving element or group of receiving elements;

separating using splitting and filter means the component signals intended for a first base station, and amplifying said component signals using amplification means;

applying a complex weight or weights to at least one of the component signals in the first base station, thereby changing the phase and/or amplitude

of the component signal relative to at least one other of the component signals;

combining the component signals in a beamformer in the first base station to produce a receive beam formed in a direction governed by the complex weight or weights.